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(54) Artifical tooth

(57) An artifical tooth (10) comprises an anchorage member (11) formed of a composite material having compatibility with living tissues; a hollow metal base member (13) set into the anchorage member (11) and protected by the anchorage member (11) from contact with aveolar bone when the tooth is implanted into a jaw; a metal post (14), for mounting a tooth crown (21) inserted into the hollow opening (12) of the metal base member (13); and at least two mutually spaced elastic buffer members (16, 17) maintaining a space (15) between the metal base member (13) and the metal post (14). The composite material having compatibility with living tissues contains 40% to 95% by weight of calcium phosphate compound and 60% to 5% by weight of an organic polymer. The elastic buffer members (16, 17) preferably movably anchor the metal post (14) in the metal base member (13) and form a cushion by which pressure imposed upon the artificial tooth (10) is transmitted to the anchorage portion (11).

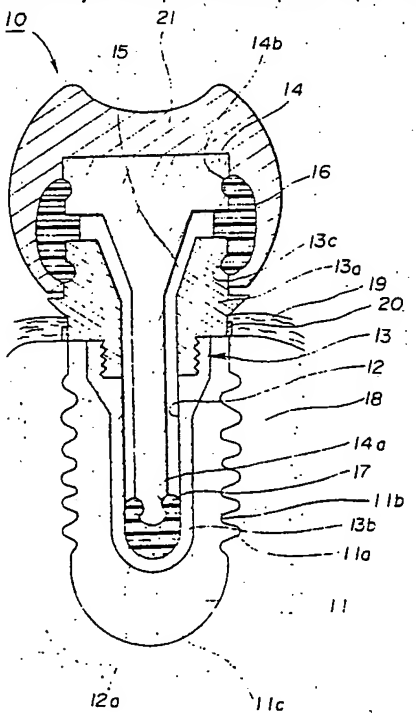

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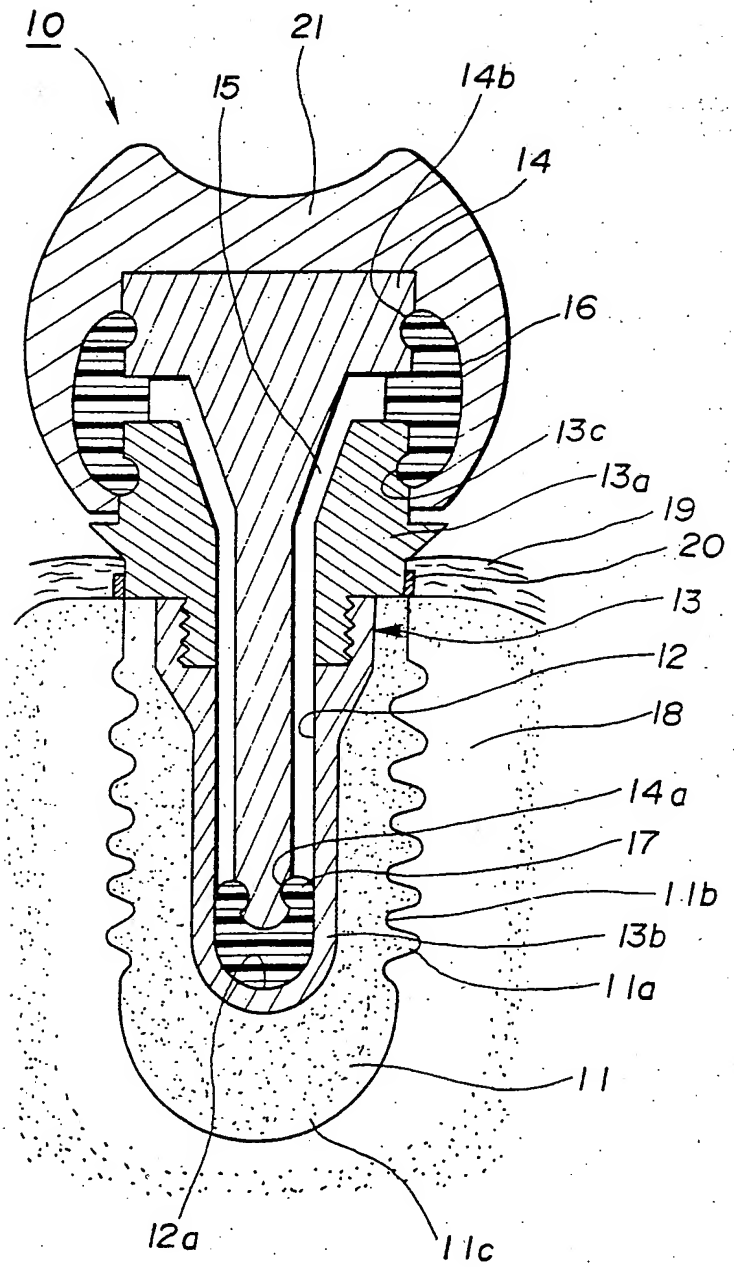
FIG.


10
21
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14b
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12a
11c

TITLE

Artificial Tooth

BACKGROUND OF THE INVENTION

This invention relates to an artificial tooth for substituting a natural tooth lost by dental diseases.

Up to the present, metals such as titanium and ceramics such as alumina or hydroxyapatite, have been utilized as the materials for artificial teeth. However, artificial teeth made of metals present problems in biocompatibility since they tend to be attacked and dissolved in the living tissues, while being higher in hardness and modulus of elasticity than those of the bone tissue. Artificial teeth made of ceramics also present problems with respect to brittleness, hardness and machinability.

An artificial tooth comprising a metal core and a cermaic coating applied to the core has also been produced and offered to the market. However, these artificial teeth have not been used extensively because of the rather weak connection between the metal and the ceramic.

For overcoming the above problems, there has recently been evolved an artificial tooth including an outer anchorage portion which is formed of a composite material exhibiting biocompatibility and which is disposed in contact with the alveolar bone, a hollow metal base member set into the anchorage member, and a metal post held in the hollow interior of the base member by an elastic buffer material which completely fills the gap between the metal post and the metal member (Japanese Unexamined Patent Publication No. 152449/1987). This artificial tooth has a drawback that it does not nec ssarily produce a sufficient buffer action such that the extent of possible movement of the

metal post under tooth pressure is less than that of the natural tooth.

SUMMARY OF THE INVENTION

It is an object of the invention to overcome the above drawback. Accordingly the invention provides an artificial tooth comprising an anchorage member formed from a composite material which is compatible with living tissues comprising from 40% to 95% by weight of a calcium phosphate compound and from 60% to 5% by weight of an organic polymer; a hollow metal base member set into the anchorage member and protected by the anchorage member from contact with alveolar bone when the tooth is implanted into a jaw; and a metal post for mounting a tooth crown, received within the hollow of the base member but spaced therefrom and cushioned with respect thereto by at least two mutually spaced elastic buffer members.

Other desirable properties of the artificial tooth of the invention are that it should be capable of easy manufacture and implantation, and that it should be durable and permit easy replacement of damaged or worn components. Preferably implantation should be possible by an operation that will rarely cause inflammation in the gingiva.

Preferably the artificial tooth of the invention should make it possible to reunite the gingival mucosa or epithelial tissue and the artificial tooth when the adhesion therebetween is lost or injured.

The attainment of the above preferred objects is illustrated with reference to the drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single figure is a diagrammatic sectional view showing an artificial tooth according to the present invention.

PREFERRED EMBODIMENT OF THE INVENTION

An artificial tooth 10 according to the present invention includes an anchorage member 11 made of a composite material which is compatible with living tissues and a hollow metal base member 13 having an opening 12 therein set into the anchorage member 11 which insulates it from contact with alveolar bone 18 when the tooth 10 is implanted in a jaw. A metal post 14 is received in the hollow opening 12 of the metal base member 13 and at least two elastic buffer members 16, 17 spaced apart from each other are disposed in a space 15 between the metal base member 13 and the metal post 14.

The composite material from which the anchorage member 11 is formed is a material comprising from 40% to 95% by weight of a calcium phosphate compound and from 60% to 5% by weight of an organic polymer. It has been found that if the composite material were to comprise less than 40% by weight of the calcium phosphate compound growth of new bone would be retarded and it would take an excessive time until the composite material became unified with the alveolar bone. If the composite material were to comprise more than 95% by weight of the calcium phosphate compound, difficulties would be presented in machining and hence in the industrial mass production of the artificial teeth. The composite material used in this invention, utilizing a range of 40% to 95% by weight of the calcium phosphate compound, results in a large amount of new bone being formed around the artificial tooth material, thereby obtaining physical properties of the artificial tooth close to those of natural bone. In addition, the artificial tooth exhibits a modulus of elasticity close to that of a natural tooth, and the anchorage portion has a good machinability so that artificial teeth of a predetermined size may be mass-produced.

Examples of calcium phosphate compounds which may be used include tricalcium phosphate, hydroxyapatite, tetracalcium phosphate, oxyapatite, calcium pyrophosphate, fluoroapaptite, compounds in which hydroxyl groups of hydroxyapatite are partly substituted by fluorine ions, brushite ($CaHPO_4.2H_20$) and mixtures thereof. Among these calcium phosphate compounds, preferred compounds which give rise to faster rates of formation of new bone include tricalcium phosphate, hydroxyapatite, fluoroapatite and tetracalcium phosphate. Above all, hydroxyapatite results in the fastest rate of formation of new bone and therefore is most preferred among these compounds. Advantageously the hydroxyapatite is obtained upon heat treatment at a temperature of not lower than 500°C, desirably not lower than 700°C since it has an outstanding high rate of formation of new bone. Although there is no upper limit temperature for heat treatment, hydroxyapatite starts to be decomposed at too high a temperature so that heat treatment should be carried out at lower than the decomposition temperature of hydroxyapatite. The calcium phosphate compounds that may be used in the present invention may be either artificially synthesized compounds synthesized by any known methods, such as the wet, dry and hydrothermal methods, or compounds of natural origin obtained from human or animal bone. The calcium phosphate compounds used in the present invention may be powdered, granular or in the form of a porous body, on the condition that the compounds are miscible with monomers of the organic polymers.

There is no specific limitation to the organic polymers that may be used, except that they should not be toxic to the living body and should exhibit affinity with the calcium phosphate comp unds. Thus, for example, the organic polymer may be chosen from carboxylic acid type polymers, such as polylactic acid or polyglycolic acid,

carboxylate type polymers such as polymethylmethacrylate (abbreviated hereinafter to PMMA) or poly(trifluoroethyl methacrylate) (abbreviated hereinafter to PTFEMA) or olefinic polymers, such as polyethylene or polypropylene. Among these polymers, PMMA and PTFEMA exhibit higher affinities with calcium phosphate compounds and high strength and hence are particularly preferred. Above all, PTFEMA exhibits the highest affinity with calcium phosphate compounds and hence is most preferred.

The composite material may be produced by mixing and stirring a paste containing the polymer and the monomer of the organic polymer with the calcium phosphate compound and polymerizing the mixture by heating.

The composite material employed in the present invention is endowed with properties indispensable to the artificial tooth 10, that is, compatibility with living tissues, elasticity and machinability of the tooth material. Although the contacting member 11 may have a smooth outer surface, an indented surface presenting alternate projections 11a and recesses 11b as shown in the figure is preferred since the stress produced during mastication is distributed and released due to the increased bonding area between the composite material and the new bone, while the load applied to the bone tissues is reduced. A helical configuration of the projections 11a and the recesses 11b is most desirable since the artificial tooth 10 can be secured positively as soon as it is buried in the alveolar bone 18. Although the bottom section 11c of the contacting member 11 may be formed as a flat surface, a hemispherical shape of the bottom 11c as shown in the figure is most preferred since it promotes distribution of the stress during mastication.

The artificial tooth 10 of the present invention is provided with the hollow metal base member 13 set into the anchorage member 11. The metal post 14 is introduced into the hollow opening 12. The hollow metal base member 13 and the metal post 14 may be formed of known biocompatible metal materials, such as titanium, cobalt-chromium alloy or stainless steel (type 316L), as long as the metals satisfy the conditions of strength and hardness required of the artificial tooth 10. The metal base member 13 may be made in one or two parts, as long as it is provided with its hollow opening 12 into which the metal post 14 can be introduced. The metal base member 13 of the figure is in two parts, namely an upper section 13a and a lower section 13b, of which the lower section 13b is embedded in the anchorage member. In general the upper and lower sections 13a, 13b may be connected together by any method known in the art. A screw-threaded connection is illustrated in the figure.

When such a two-part hollow metal base member 13 is employed, the operation of implanting the artificial tooth 10 of the present invention is performed as a two step type operation, namely: a first step of implanting the anchorage member 11 and the lower hollow base member section 13b completely in the alveolar bone 18, covering the anchorage member 11 and the lower section 13b with gingival mucosa 19 and allowing them to become completely unified with the bone; and a second step of performing a dental operation of removably securing the upper section 13a and the metal post 14 to the lower member 13b such as by the screw-threaded connection shown in the figure. Two-part metal base members 13 are particularly preferred since bacterial infection and funnel-shaped absorption of the alveolar bone around the embedded artificial tooth 10 may be prevented, and the parts can be exchanged easily whenever it is necessary to exchange them due to damage or prolonged usage of the artificial tooth.

It is preferred that the portion of the metal base member 13 containing the gingival mucosa 19 be as smooth as possible. A high polymer biocompatible material 20, such as collagen or fibronectin, which is placed at the portion of the metal base member 13 contacting with the gingival mucosa 19, is highly effective to prevent gingivitis. The material 20 is preferably affixed to the lower region of contact between the metal base member 13 and the gingival mucosa 19 such as by plasma polymerization. The metal base member 13 and the metal post 14 may be fabricated by any known methods such as turning or electric discharge processing.

Two buffer members 16, 17 separate the metal post 14 from the metal base member 13. The buffer member 16 surrounds the top end portions of the post 14 and base member 13 and extends partially between the two members to establish a spacing 15 therebetween. The buffer member 17 is positioned at the bottom of the hollow opening 12 in the base member 13 and receives and locates the bottom end of the post 14, also to establish and maintain the spacing 15 therebetween. Thus the tooth pressure applied to the artificial tooth 10 during mastication is resiliently transmitted through the buffer members 16, 17, to the base member 13 and the jaw. In other words, the artificial tooth 10 will display properties close to those of a natural tooth, resulting from a sufficient extent of movement of the metal post 14.

Although the location and the number of the elastic buffer members 16, 17 may be selected optionally depending on the position of the tooth under treatment and the set of teeth, the buffer members may be placed at any mutually spaced positions in the gap or void 15 between the metal base

member 13 and the metal post 14, as long as a sufficient buffer action with respect to the tooth pressure may be achieved. However, for procuring a sufficient extent of movement of the metal post 14, the mutual spacing of the elastic buffer members 16, 17 is essential in order to maintain a gap or void in the space 15. When the elastic buffer members 16, 17 are arranged in this manner, a sufficient extent of movement of the metal post 14 and a sufficient buffer action may be achieved.

Although no specific limitation is placed on the shapes of the elastic buffer members 16 and 17, the illustrated arrangement is highly satisfactory. The buffer member 17 is shaped to engage in an annular recess 14a formed around the bottom end portion of the post 14 as shown in the figure. Also a similar annular recess 14b is formed around an upper portion of the metal post 14, and a further similar annular recess 13c is formed around an upper section 13a of the metal base member 13. The recesses 14b, 13c receive inwardly facing annular beads of the elastic buffer member 16 as shown in the figure, in such a manner that the buffer members 16 and 17 not only perform their buffer action but also connect the metal post 14 to the metal base member 13.

By using the elastic buffer members 16, 17 to interconnect the component parts of the artificial tooth, the dimensional tolerances for the metal base member 13 and the metal post 14 may be less strict than in conventional artifical teeth, so that the design and manufacture may be facilitated.

As the elastic buffer materials employed in accordance with the present invention, synthetic rubbers, such as polyurethane rubber, polyfluoroethylene rubber or fluorine

type rubber, or silicone rubber, having Young's moduli of 2 to 250 kg/cm^2 and desirably 40 to 180 kg/cm^2, are preferably employed. Practically any elastic material having durability and high strength may be empolyed. Buffer materials having different values of the modulus of elasticity may be employed depending on the locations in which the buffer members 16, 17 are placed within the space 15 for realizing the desired delicate buffer action with respect to the tooth pressure.

The anchorage member 11 and the metal base member 13 can be secured to each other by any commercial dental adhesive, such as methyl methacrylate type adhesives, sold by Morita Co. Ltd. under the trade name of 'Superbond C + B'. The elastic buffer members 16, 17 between the metal base member 13 and the metal post 14 may be coated directly onto the surfaces of the metal base member 13 and/or the metal post 14 or may be contoured specifically as described hereinabove for form-locking and fitting to the metal base member 13 and the metal post 14. A tooth crown 21 is affixed to the metal post 14 using the aforementioned adhesive.

The artificial tooth described above and illustrated in the figure is superior to known artificial teeth in its compatibility with living tissues and has high strength and a sufficient extent of movement so that it exhibits the properties close to those of the natural tooth. Also it is easy to manufacture and can be empolyed for extended times subject to exchange of damaged or worn components. Moreover, the artificial tooth of the present invention lends itself to facilitated dental operations, while it is effective to prevent gingivitis.

EXAMPLES OF THE INVENTION

The present invention will be explained in more detail with reference to an Example and a Comparative Example which are by way of illustration only.

EXAMPLE

As shown in the figure, a contacting member 11 formed of a composite material containing 78% by weight of hydroxyapatite and 22% by weight of PTFEMA and a lower section 13b of the metal base member 13 formed of titanium were affixed together. The resulting assembly was implanted in place of a tremolar tooth of a dog, being buried in direct contact with the alveolar bone 18 so that the upper edge of the assembly was flush with the upper edge of the bone 18. The assembly thus buried was then covered completely with a gingival mucosa 19. After the contacting member 11 and the alveolar bone 18 had knitted together, the gingival mucosa 19 was opened and an upper member section 13a of the metal base member 13 was screwed into the lower section 13b. A piece of collagen 20 was previously affixed by plasma polymerization to the upper section 13a so that the collagen 20 as high molecular biomaterial was located between the upper section 13a and the gingival mucosa 19 and intimately contacted the gingival mucosa 19.

An elastic buffer member 17 was fitted into a recess 14a of the metal post 14 which was then introduced in this state into the opening 12 of the metal base member 13. The two annular beads on the ring-shaped elastic buffer member 16 fitted into an annular recess 14b in the metal post 14 and into an annular recess 13c of the upper section 13a, to anchor the metal post 14 to the upper section 13a. A tooth crown 21 was finally applied to the metal post 14.

As shown in the figure, a space 15 was formed between the metal base member 13 and the metal post 14. As a result, satisfactory occlusion and the feel similar to that of a natural tooth were obtained. An X-ray inspection has revealed that the alveolar bone 18 and the artificial tooth 10 were unified together and there occurred no funnel-shaped absorption.

Comparative Example

An elastic material completely filled a space between an integral metal base member (not a split type as in the Example) and a metal post so that no space existed therebetween. The resulting tooth anchorage was buried by a one-step operation instead of by a dual-step operation as in the Example since the dual step dental operation could not be performed. Sufficient pressure releasing effect could not be obtained, such that, upon X-ray analysis, funnel-shaped absorption was seen to have taken place in the alveolar bone. Ultimately, the artificial tooth was rejected and dropped out.

CLAIMS

1. An artificial tooth comprising an anchorage member formed from a composite material which is compatible with living tissues comprising from 40% to 95% by weight of a calcium phosphate compound and from 60% to 5% by weight of an organic polymer; a hollow metal base member set into the anchorage member and protected by the anchorage member from contact with alveolar bone when the tooth is implanted into a jaw; and a metal post for mounting a tooth crown, received within the hollow of the base member but spaced therefrom and cushioned with respect thereto by at least two mutually spaced elastic buffer members.

2. An artificial tooth according to claim 1, wherein the calcium phosphate compound is hydroxyapatite.

3. An artificial tooth according to either preceding claim, wherein the organic polymer is polylactic acid, polyglycolic acid, polymethylmethacrylate, poly(trifluoroethyl methacrylate), polyethylene, polypropylene or a mixture thereof.

4. An artificial tooth according to any preceding claim, wherein the outer side surface of the anchorage member is ribbed.

5. An artificial tooth according to claim 4, wherein the outer side surface is formed with a spiral rib.

6. An artificial tooth according to any preceding claim, wherein the bottom end of the anchorage member is hemispherical.

7. An artificial tooth according to any preceding claim, wherein the hollow metal base member comprises a lower

section embedded in the anchorage member and an upper section removably connected to the lower section and outstanding from the anchorage member.

8. An artificial tooth according to claim 7, wherein the upper section and the lower section are screw-threadedly connected to each other.

9. An artificial tooth according to any preceding claim, wherein a high polymer biocompatible material surrounds the hollow metal base member in the region which in use would come into contact with a gingival mucosa (19).

10. An artificial tooth according to any preceding claim, wherein one or both of the elastic buffer members anchors the metal post in the metal base member.

11. An artificial tooth according to any preceding claim, wherein a crown (21) is attached to the metal post (14).

12. An artificial tooth according to claim 1, substantially as described herein with reference to the sole figure of the drawing.

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